CIFE

Industry Advisory Board Meeting

CIFE Industry Advisory Board Meeting

8:00 Welcome coffee

8:30 Update on CIFE business and research and education activities

9:15 Discussion of CIFE update and decisions

10:00 -- Break --

10:30 CIFE member updates on successes, initiatives, and challenges and discussion

12:30 -- Lunch --

13:30 Potential initiatives for the CIFE community for the next 24 months

14:00 Breakout groups to develop the most promising initiative

15:15 Reports from breakout groups and discussion

16:15 Vote to determine the highest value initiatives for the CIFE community

16:30 Summary of the decisions taken including reflection on voting and next steps

17:00 – Open House/Meet with Students --

18:30 -- Informal Dinner --

Topics

- Advice
- People
- Stanford Context
- Money
- Members
- Events
- Teaching
- Research

Advice

- VDC Certificate Program
  - Leave as is (1-2 open sessions, dedicated sessions as demand and capacity allow
  - Offer only dedicated sessions on demand
  - Executive Program
- Seed Project Process
  - Leave as is
  - Flagship projects
- Sustainable Urban Systems
  - Role of CIFE?
- BuiltX
  - Accelerating startups that improve the built environment
- Partnerships
- Research focus

People: John Kunz retired

People

Visiting Fellows & Interns

Austin Becker (WDI)

Ramon Iglesias (Mortenson)

Hal Rolnick (RIB)

Devini Senaratna (Glodon)

Min Song (CCC)

George Venetsanopoulos (CCC)

Tongda Zhang (DPR)

Plus many summer interns

Research Associate

Forest Flager

Consulting Professors

Vladimir Bazjanac (LBNL)

Calvin Kam (bimSCORE)

Bill McDonough

Ben Schwegler (WDI)

Visiting Scholars

Patrick Shiel, Apr 2013 – Mar 2015

Sérgio Scheer, Oct 2014 – Sept 2015

Lea Urup, Jan. 2014 – June 2014

Stanford Context

- Graduate Construction Program is strong
- 5 tenure line faculty
- 31 lecturers and consulting professors
- 111 graduate students
  - 73 MS
  - 38 post MS

- New School of Engineering Leadership

Persis Drell

Jennifer Widom

- Sustainable Urban Systems Initiative

Stanford Construction Curriculum Overview

- **Overview of Program Curricula**
  - SDC – Management (Formerly CEM)
  - SDC – Energy (Formerly SDC)
  - SDC – Structures (Formerly DCI)
  - SDC – Water (New)
- **Related Undergraduate Program**
  - Architectural Design
- **Related Centers and Labs**
  - Center for Integrated Facility Engineering (CIFE)
  - Project Based Learning Lab (PBL)
  - Global Projects Center (GPC)
  - Sensing, Data Analytics, and Optimization

Sustainable Urban Systems

VISION

Students will learn to create integrated urban infrastructure systems in a re-conceptualized educational setting.

Traditional: Separate power plants & Wastewater treatment

Integrated: Clean the water while producing fuel, fertilizer and plastics

SUS Program Elements: Team Project

Company

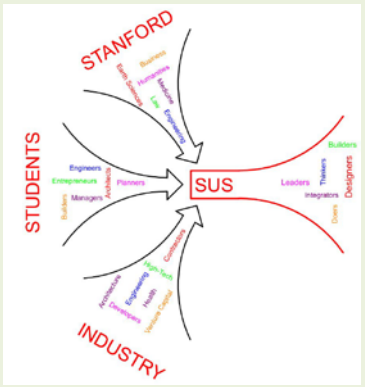
Executives

Industry and Faculty Mentors

SUS Students

Company Support:

- Student RA-ships
- Student internships
- Field trip(s)
- Mentors (in kind)



Sources of Membership and Program Income

- Contributor $15,000
- Small Business $12,000
- Member $35,000
  - $15k discount for tech companies
- Visiting Fellow $20,000
  - $18,750 with partner discount
  - 1-3 VF Quarters: Associate Member
  - 4+ VF Quarters: Partner

- VDC Certificate Program
  - $75,000 per program (with partner SPS/PPI)
  - ~25 participants
- Other Events

Currently 33 CIFE Members
Changes since last IAB

NEW MEMBERS

Bentley Software
Implenia Schweiz
MT Højgaard
Nemetschek Allplan
Royal HaskoningDHV
Synchro Software

CHANGE IN MEMBERSHIP LEVEL

CCC	Associate → Partner
DPR Construction	Member → Associate
Parsons Brinckerhoff	Associate → Member
Skanska	Member → Contributor
SMART Technologies	Associate → Member

FORMER MEMBERS

Cadwork Informatik
Oracle Primavera
Slavenburg BV

Teaching: Major Stanford Courses with Significant CIFE Content and Industry Participation

- CEE220 BIM series
  - Autodesk
- CEE212 Industry Applications of VDC
  - Bechtel
  - bimSCORE
  - CCC
  - GSA
  - Mortenson
  - Obayashi
  - Walt Disney Imagineering
  - AIA
  - NASA
  - Smithsonian
  - Swiss VDC program participants
- CEE222 Computer Integrated AEC Global Teamwork
  - Too many to list here
- CEE241 Managing Fabrication and Construction
  - RIB
  - Trimble
  - CCC
  - Clark Pacific
  - DPR
  - Webcor

Teaching: Educational Events for the CIFE Community

- 62 VDC Certificate Program Graduates last year
- 7 VDC Certificate Courses
  - WDI Dec. 13
  - WDI Feb. 14
  - Veidekke Mar. 14
  - Implenia May 14
  - CIFE Jun. 14
  - Singapore Jun. 14
  - PB online Apr.-Sep. 14
  - *RHDHV Dec. 14*
  - *China Mar. 15*
  - *Peru Mar. 15*
  - *NCC Aug. 15*
- Other Events
  - Strategy Meeting Oct. 13
  - Parts List Workshop Mar. 13
  - Key Performance Indicators Mar. 13
  - Summer Program Jun 14
  - VDC Workshop Hong Kong CIC Sep. 14
  - Facility Energy Management Workshop Sep. 14
  - *Tongji VDC Conference Shanghai Oct. 14*
  - *iTWO World Hong Kong Nov. 14*
  - *BIM Seminar Zurich Jan. 15*
  - *3rd BIM Conf. Dubai Feb. 15*

Proposed CIFE Calendar 2014-15

EVENTS	DATES
Call for Seed Proposals	March 4
Proposals Due	April 22
Technical Advisory Committee	April 30
Summer Program	September 9-10
Industry Advisory Board	October 15
VDC Certificate Program	???

2013-14 CIFE Seed Projects

- Space Constraint Method – *M. Fischer, M. Lepech, R. Morkos ($30,000)*
- Using MDO to Support Sequential Conceptual Design Decisions – *M. Lepech, M. Fischer, F. Flager, J. Basbagill* ($40,000)
- A Framework for Bringing 3D Printing into the Construction Industry – *M. Fischer, V. Bazjanac, N. Mrazovic* ($30,000)
- Integrated Virtual Parts Library - Parts List Definition – *M. Fischer, C. Kam, B. Schwegler, C. Chi, D. Hall, H. Chen, J. Wei, N. Zhao, P. Padachuri, S. Tao* ($45,000)
- Statistical Analysis of KPIs: the Missing Links in the VDC Decision Making Process – *M. Fischer, C. Kam, D. Senaratna* ($30,000)
- Enhancing Pre-Construction Decision-Making on Sustainable Commercial Building Projects – *M. Lepech, G. Griggs, K. Abraham ($30,000)*
- Achieving Large-scale Energy Reduction in Commercial Buildings Using Closed Loop Energy Analysis (CLEAN) – *M. Fischer, C. Kam, P. Shiel* ($35,000)

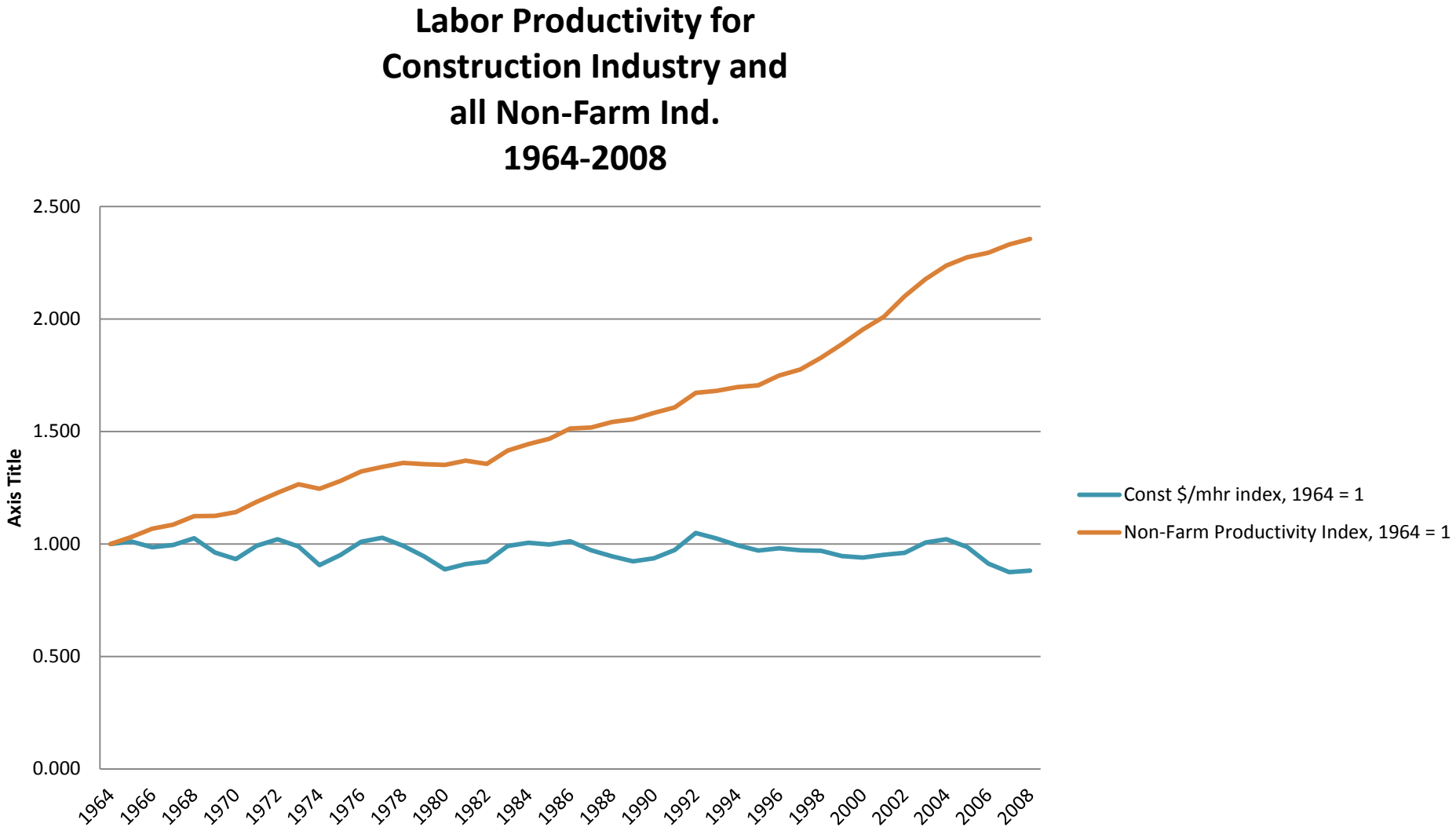
2013-14 Visiting Fellow Projects

- Austin Becker (WDI)
  - Engineering and Policy Implications of Sea Level Rise for Sea Ports
- Forest Flager, Ramon Iglesias (Mortenson)
  - Windfarm Optimization
- Hal Rolnick (RIB)
  - Global Implementation of 5D Modeling
- Devini Senaratna (Glodon)
  - VDC Scorecard
- Min Song (CCC) and George Venetsanopoulos (CCC)
  - BIM-based Construction Management
- Skyler Holloway (DPR)
  - Review of IPD Practices
- Tongda Zhang (DPR)
  - Worker Movement Analysis
- Forest Flager, Calvin Kam, Several Students (WDI)
  - Integrated Infrastructure; Optimization of Supply and Demand for Energy for Neighborhoods
  - Parts List
- Robert Gräbert, Alissa Cooperman (CBRE – RGRC)
  - Facility Energy Management Practices by Leading Owner-Operators

2014-15 CIFE Seed Projects

- Methodology for Digital Design and Additive Manufacturing of High Performance Building Façade Segment Optimized to Environmental Constraints *AND* Impact of Material Characteristics on Construction and Lifecycle Performance of Buildings – *M. Fischer, S. Billington, V. Bazjanac, N. Mrazovic ($70,000)*
- Enhancing Decision-Making on Sustainable Building Projects Using Influence Diagrams – *M. Lepech, R. Shachter, K. Abraham ($35,000)*
- Managing Construction Parts - From Manufacturing to Construction – *M. Fischer, C. Kam, B. Schwegler, C. Chi, D. Hall, H. Chen, N. Zhao, S. Tao ($50,000)*
- A Simulation-Based Approach to Accounting for Uncertainty and Variability in Look-Ahead Planning – *M. Fischer, J. Choo, N. Garcia-Lopez (35,000)*

Productivity in construction is lagging productivity in other industries!



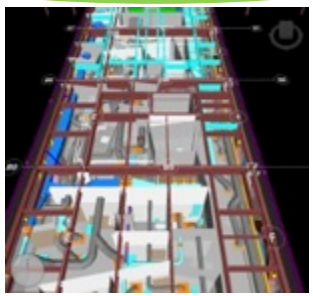
Virtual Design and Construction (VDC)

Client/Business Objectives

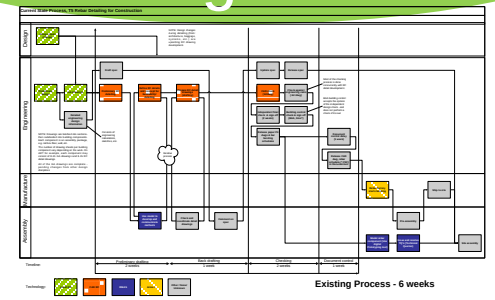
Project Objectives

Integrated Concurrent Engineering (ICE)

Product Modeling (BIM+)

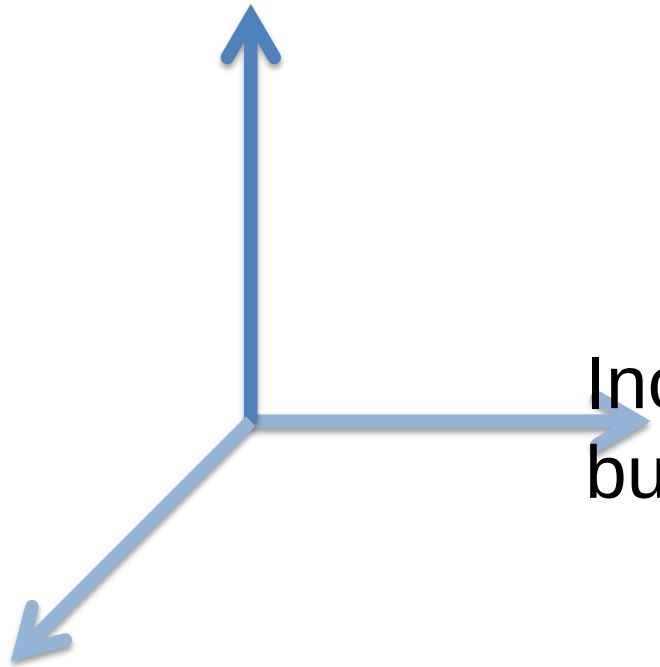


Process Modeling & Management



The ability to predict performance will be a key competitive advantage

Increase the number of **virtual** buildings or design options considered

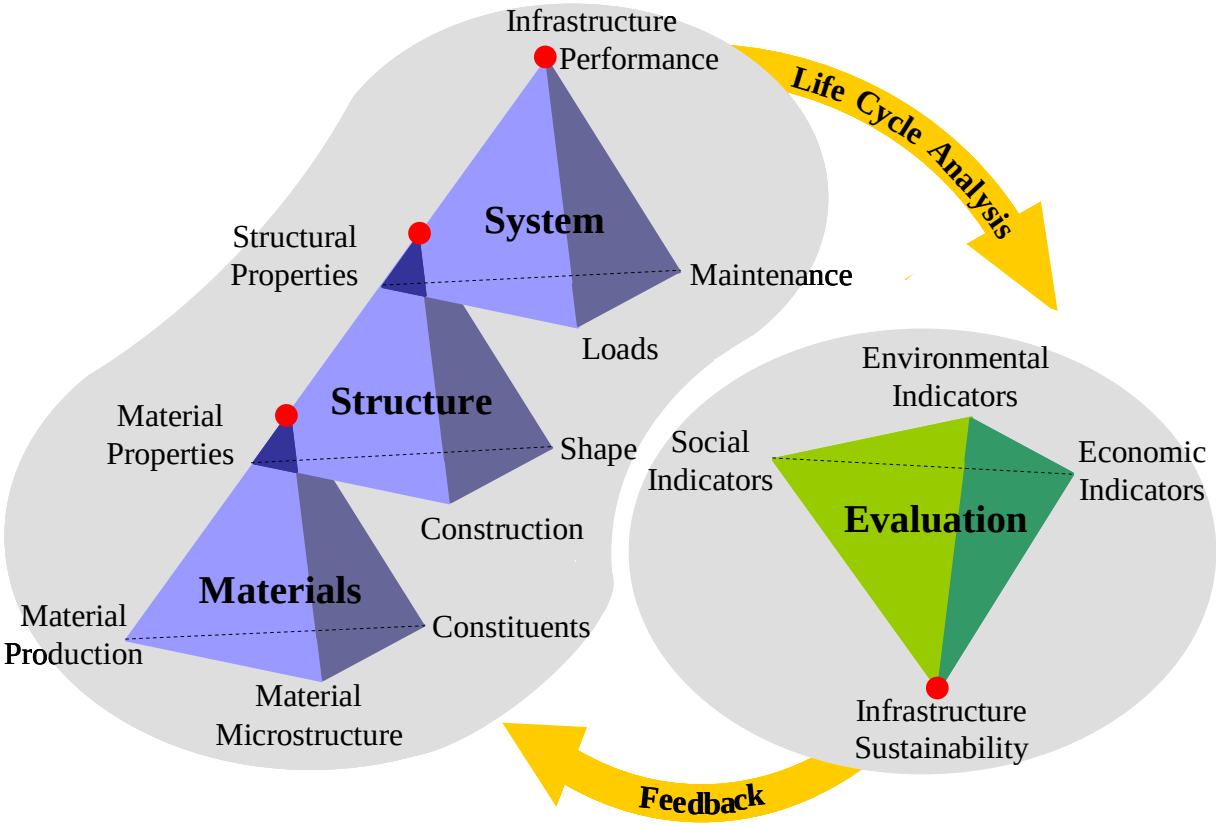


Increase the number of **real** buildings considered

Improve the **quality** of analysis and simulation **models**

Lepech Research Group

Sustainable Integrated Materials, Structures & Systems (SIMSS) Research and Design Approach



Lepech Research Group

System

Transportation Modeling and Optimization

Energy System Modeling and Optimization

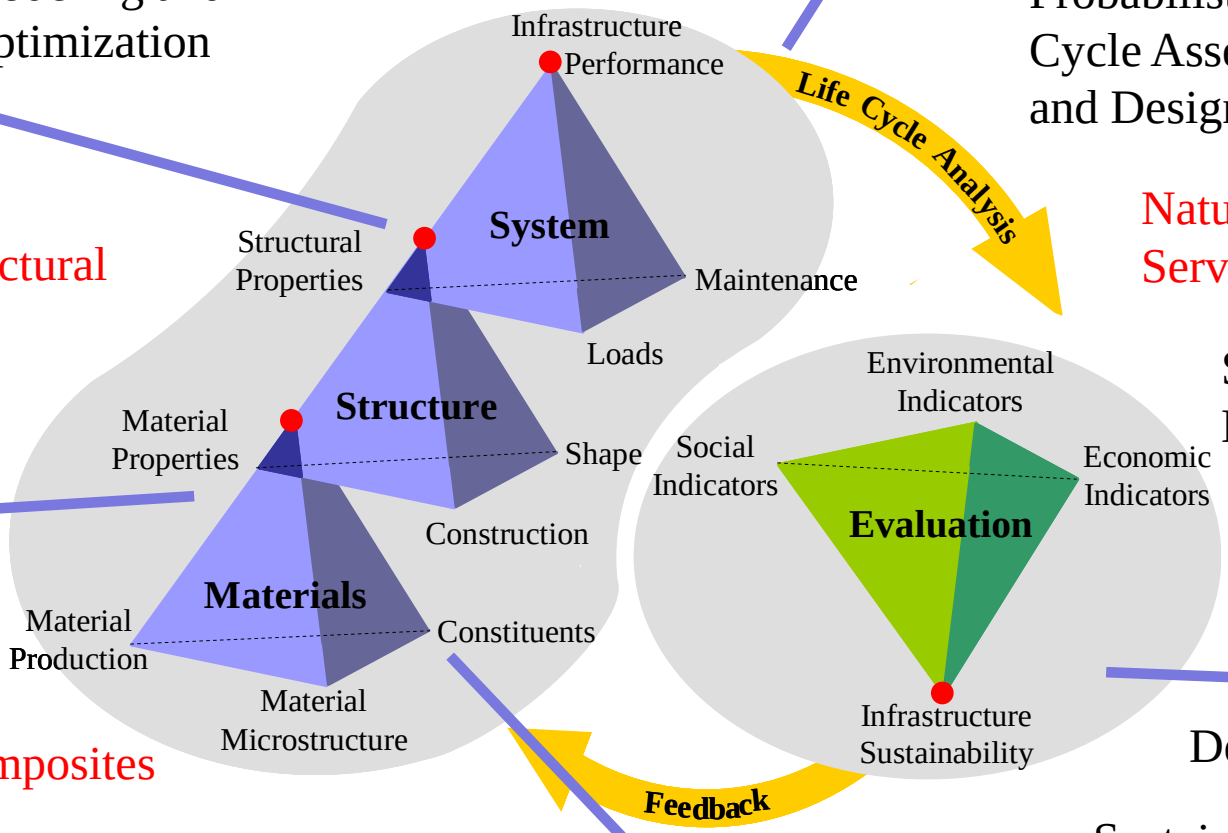
Evaluation

Probabilistic Life Cycle Assessment and Design

Structures

ADAPT Architectural Software

STV Design



Natural Ecosystem Service Valuation

Social Indicator Development

Finance Modeling

Materials

Biological Construction Composites

Decision-making

Engineered Cementitious Composites

Biological Construction Polymers

Feedback

Sustainability Indicator Visualization

STANFORD
CIVIL & ENVIRONMENTAL ENGINEERING

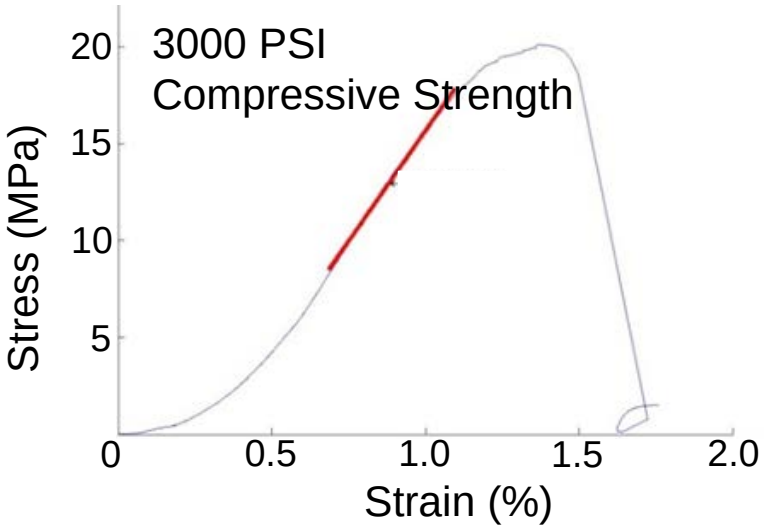
Materials – Biological Composites

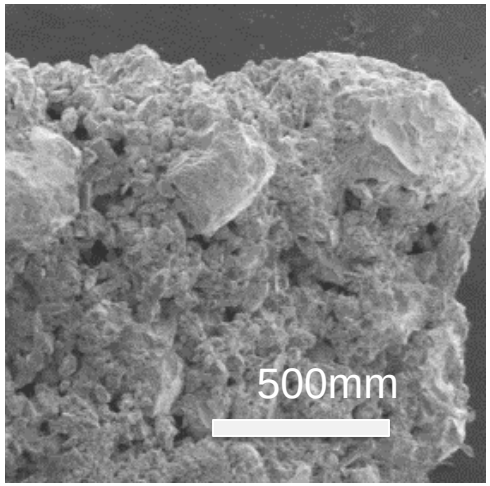
5% Engineered Protein

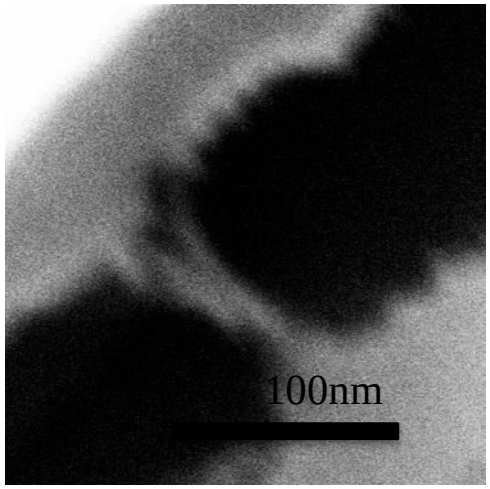
+

95% Inorganic Minerals

=



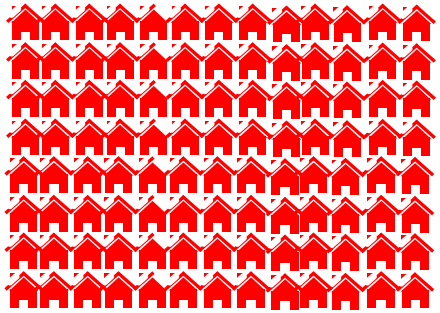


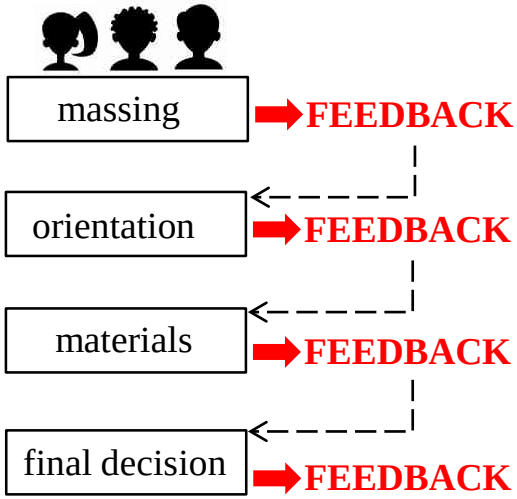


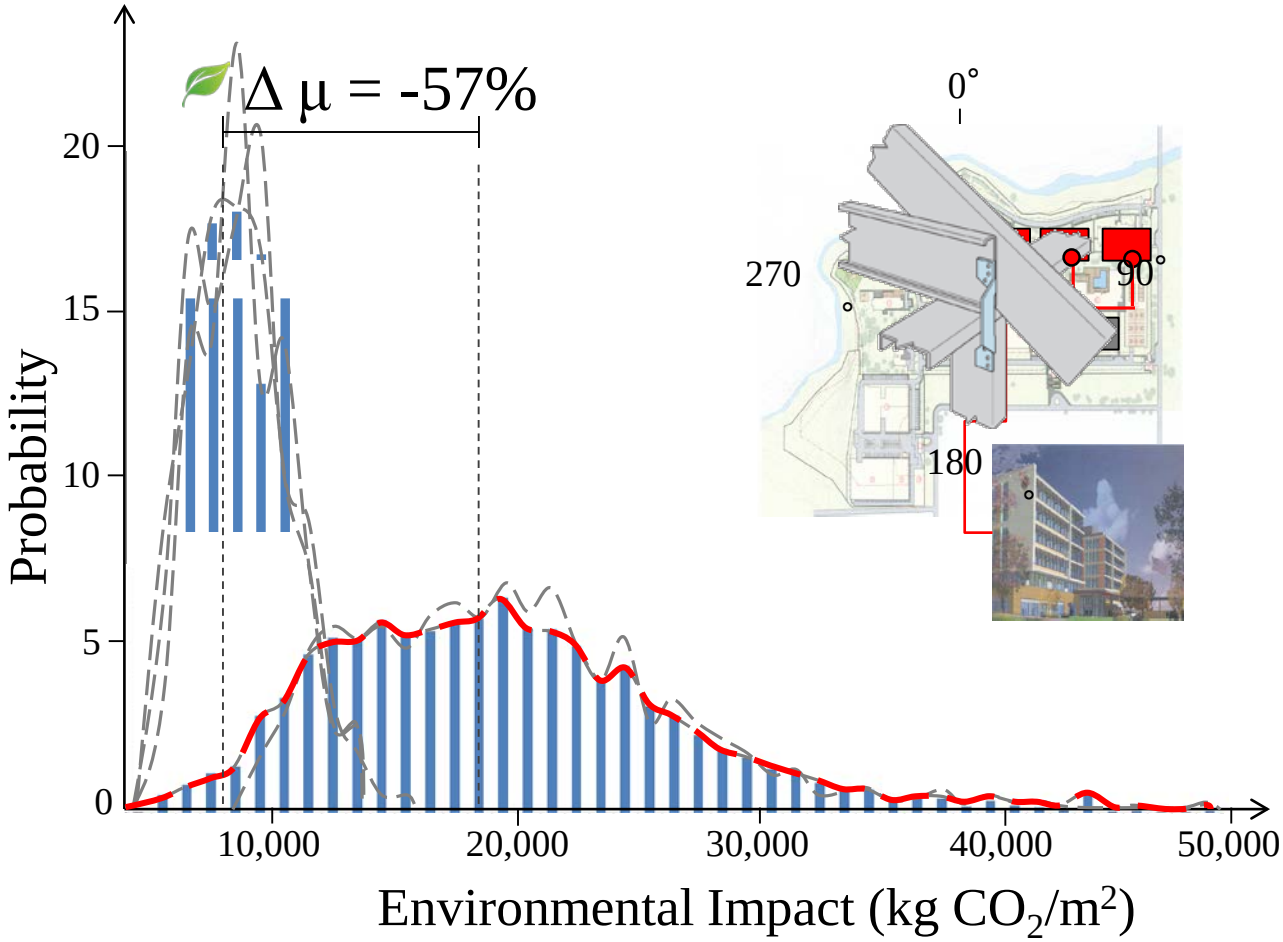
Roedel, H. *et al*. (2014) "Life Cycle Assessment of Biocomposite Bricks" International Symposium on Sustainable Systems and Technologies 2014. Oakland, California, USA. May 19-21, 2014.

Structures - ADAPT

ADAPT software allows environmental evaluation of early stage decisions (orientation, materials, *etc.*) through visualized probability mass functions.

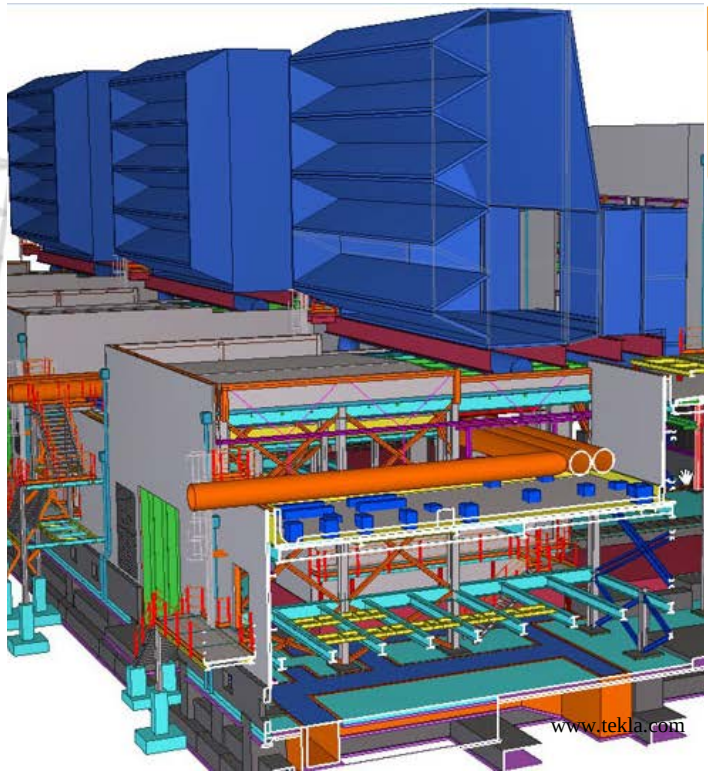






System – Energy System Modeling

www.neuralenergy.info



www.tekla.com

OPTIMIZE THE ENERGY MIX

- Fuel used:
  - Heating oil: 43%
  - Gas: 42%
  - Wood: 15%
- → Reliance on heating oil: 100% in 2000, only 40% in 2006

REDUCE ENVIRONMENTAL IMPACTS

- In 2000, installation of continuous emission measurement and analysis equipment
- Renewable energy as a percentage of the total energy consumed: 15%
- Emissions avoided:
  - 6,880 metric tons of CO_2 in 2002; 19,700 metric tons of CO_2 in 2006
  - 30% less dust particles compared with 2002
  - 44% less sulfur dioxide compared with 2002

AWARENESS OF REDUCED CONSUMPTION

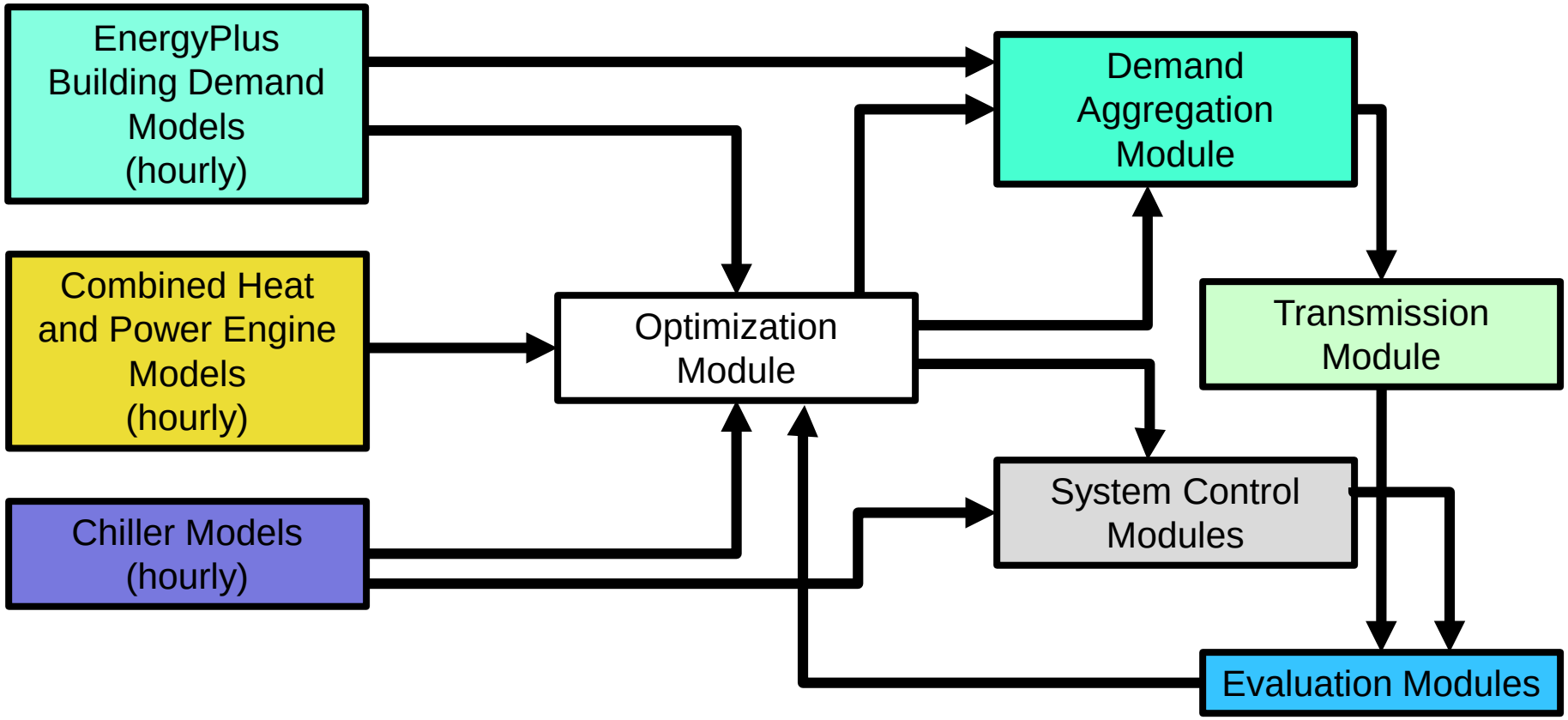
- Brochure with information to improve awareness of sustainable development and energy management

www.energylab.es

Optimized Building + Optimized Power Plant ≠ Optimized System

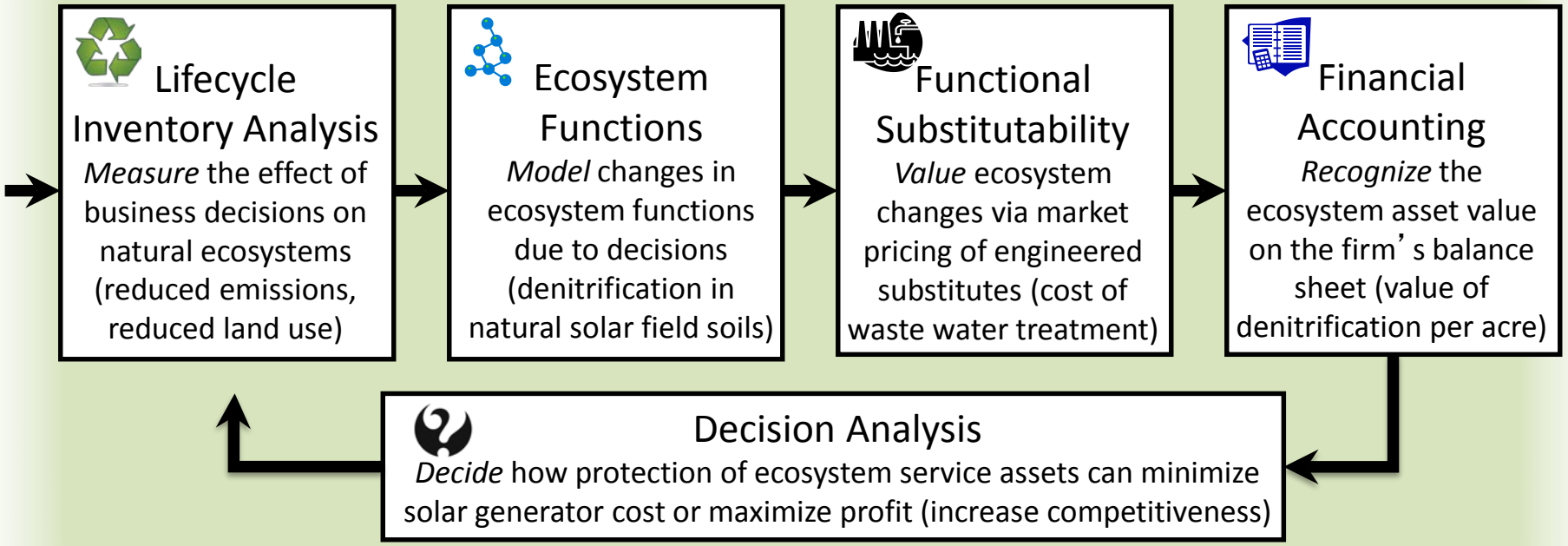
System – Energy System Modeling

Modeling and optimizing energy demand and energy generation simultaneously allows for improved efficiency across the overall system.

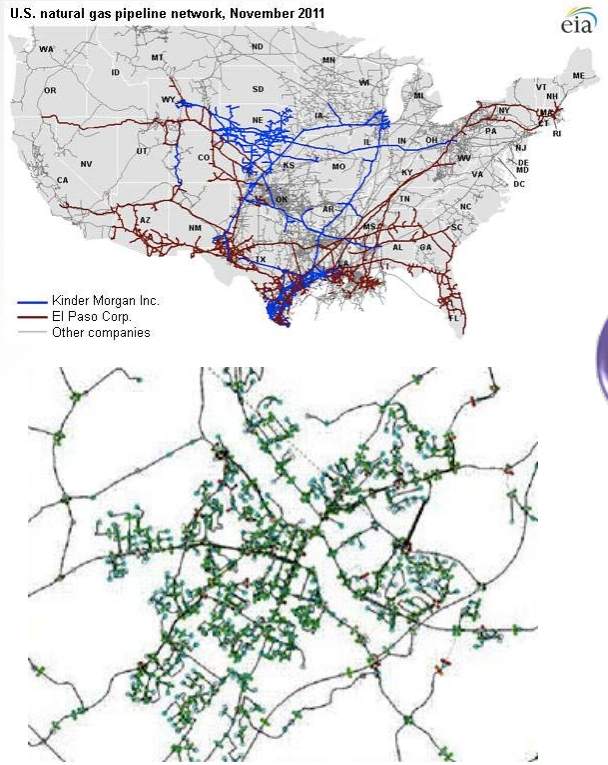


Evaluation – Ecosystem Services

Developing science-based, rigorous methods to consider the value of natural ecosystems on the financial balance sheet of private companies according to Generally Accepted Accounting Principles (GAAP).

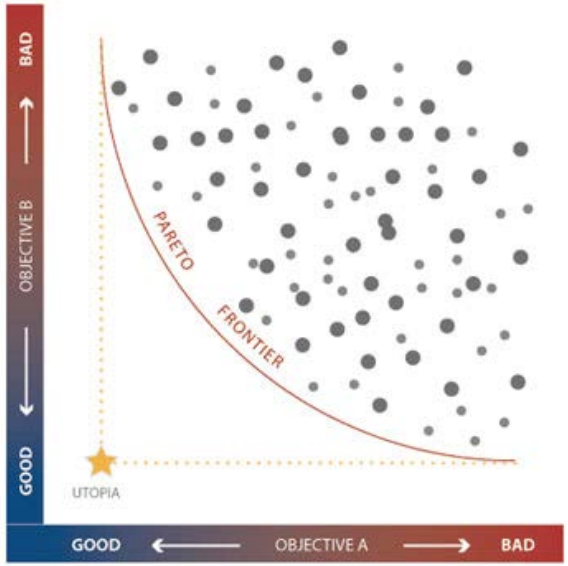


Data Analytics – Ram Rajagopal



Sensing Networks

Data Analytics



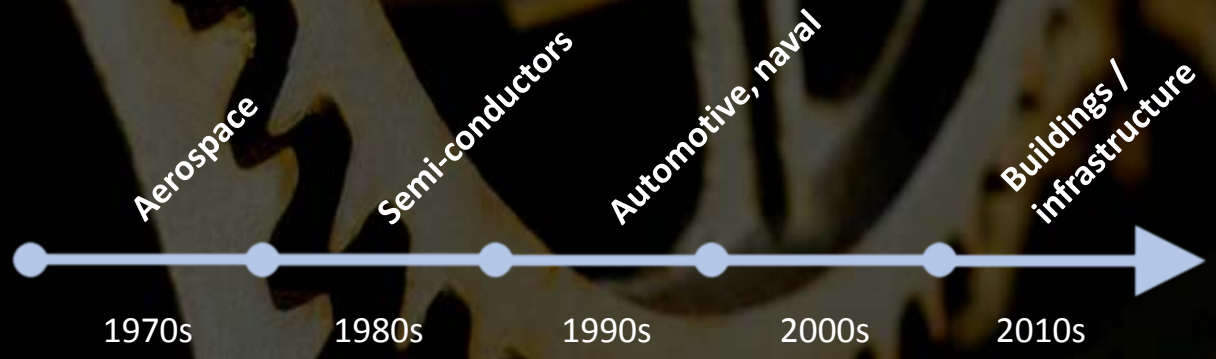
Optimization and Control

- Civil Engineering and Management Context
- Hands-on and Real World Problems

MDO
Multidisciplinary Design Optimization

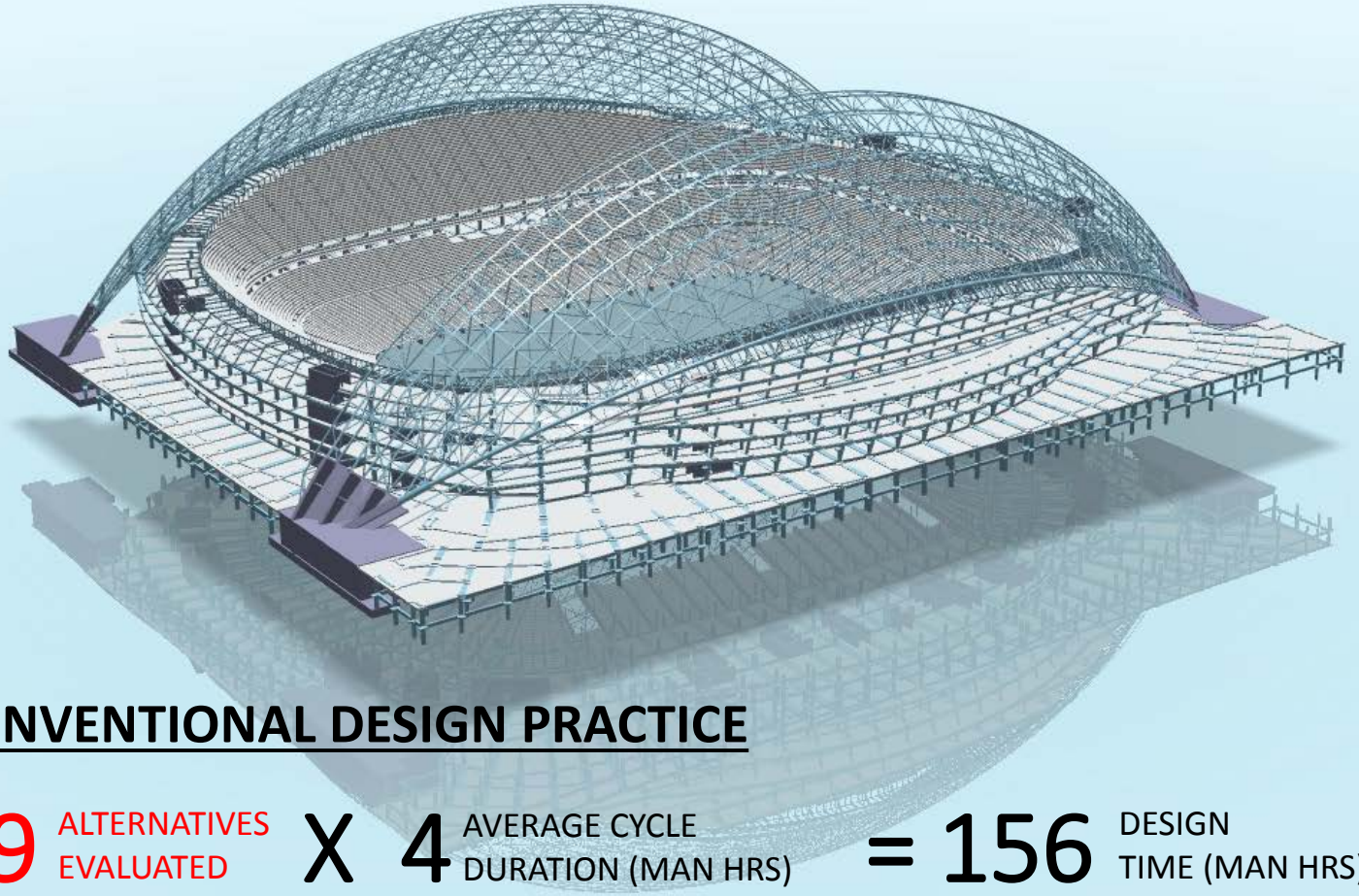
"Multidisciplinary Design Optimization involves the formalization of design iteration and coordination to leverage computer processing power to systematically search the design space"

- MDO Technical Committee, AIAA (1991)



Why?

(1955 MEMBERS)^20 CANDIDATE SECTION SIZES = 1.47 E 2487 POSSIBLE DESIGN CONFIGURATIONS



CONVENTIONAL DESIGN PRACTICE

39 ALTERNATIVES EVALUATED X 4 AVERAGE CYCLE DURATION (MAN HRS) = 156 DESIGN TIME (MAN HRS)

Why?

	CONVENTIONAL PRACTICE (ARUP)	MDO
PROCESS METRICS		
Design cycle time	4 hrs	3 sec
Alternatives evaluated	39	12,800
Set-up time	60 hrs	140 hrs
Total design time	216 hrs	151 hrs
PRODUCT METRICS		
Total Steel Weight (met t)	2,728	2,292
Est. Cost Savings (USD, Millions)	-	4 (-19%)

Why?

SCOPE

Building shell and services

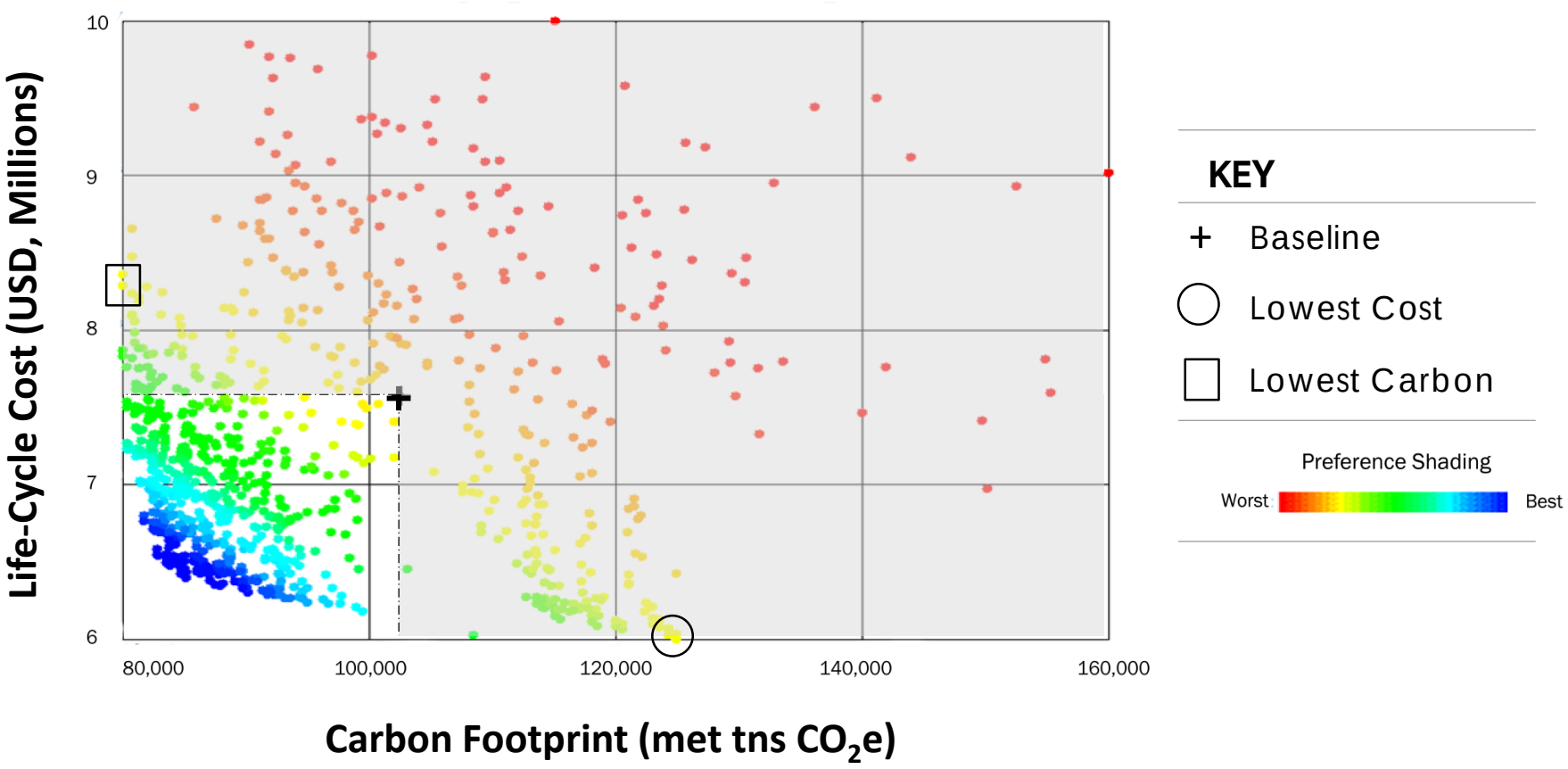
OBJECTIVES

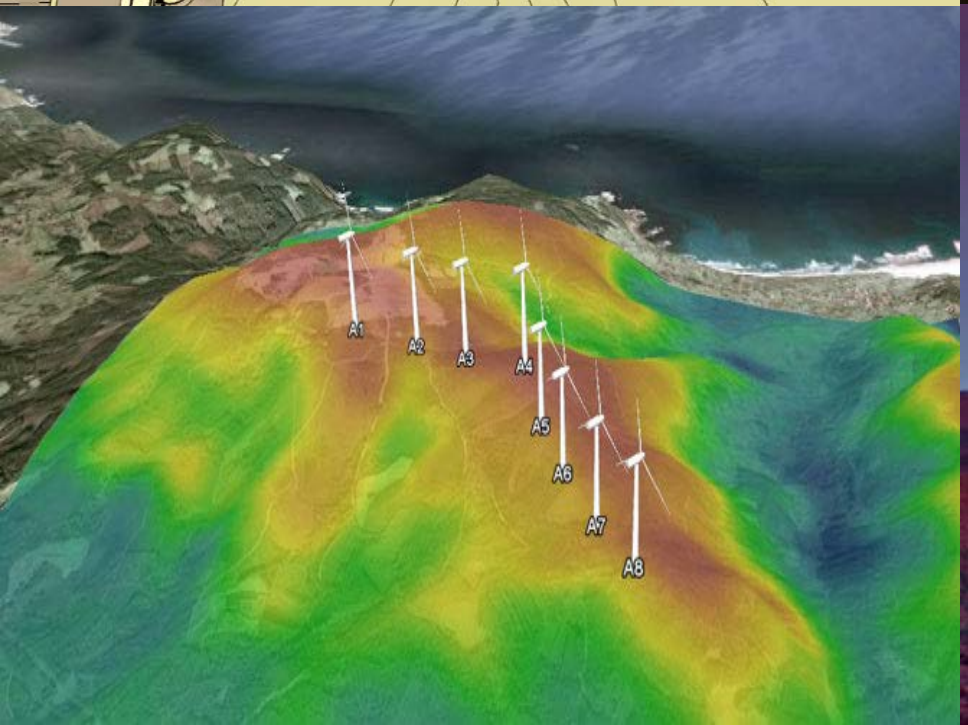
(1) Minimize life-cycle cost
(2) Minimize carbon footprint

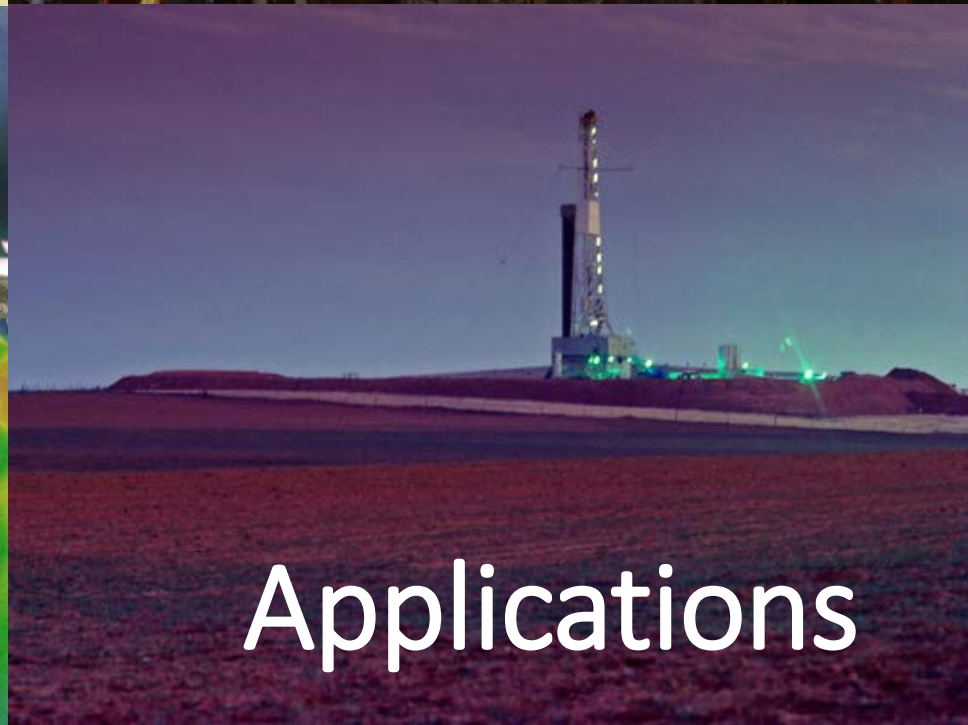
VARIABLES

(1) Building orientation: +-10°
(2) Glazing percentage: 30-70%
(3) Glazing type: 26 candidate products

Why?


Life-Cycle Cost (USD, Millions)
10
9
8
7
6
80,000
100,000
120,000
140,000
160,000
Carbon Footprint (met tns CO_2e)
KEY
Baseline
Lowest Cost
Lowest Carbon
Preference Shading
Worst
Best





Applications

CAMPUS MASTERPLANNING

Scope:
- Building position and massing

Partner:
- The Beck Group

Results:
- ⬇12% life-cycle cost
- ⬇8% carbon footprint

URBAN ENERGY SYSTEMS

Scope:
- Development size and density
- Building use composition

Partner:
- WDI

Results:
- ⬆11% primary energy efficiency

WIND ENERGY

Scope:
- Turbine layout and crane path

Partners:
- Mortenson + MAP Royalty

Results:
- ⬇7% construction cost
- ⬇3% cost of energy

OIL AND GAS

Scope:
- Work sequencing for well completion

Partner:
- Strategic Project Solutions

Results:
To be determined

Applications

Why now?

 Challenging project performance requirements

 Demand for data-driven design

 Integrated project delivery (IPD)

 Advancements in BIM and simulation

 Low cost and high availability of ‘cloud’ computing

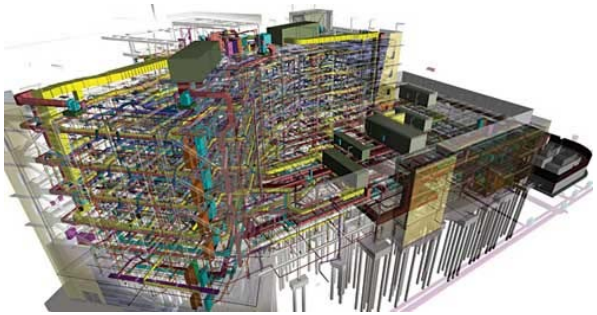
Challenges / Opportunities

OWNERS

- Greater involvement in process
- Expect data to support decisions

ARCHITECTS AND ENGINEERS

- Technology as a differentiator
- Change in designer skill set



CONTRACTORS AND SUPPLIERS

- Early Involvement
- Product data transparency
- Premium on supply chain management

Advice

- VDC Certificate Program
  - Leave as is (1-2 open sessions, dedicated sessions as demand and capacity allow)
  - Offer only dedicated sessions on demand
  - Executive Program
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- Partnerships
- Research focus
  - Outcome and Production Performance
  - MDO
  - Data Analytics
  - Integration